

# The Use of Artificial Teeth for Post-Core Techniques in a Pre-clinical Fixed Prosthodontics Undergraduate Teaching Program: An Evaluation of Student Experience

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## Abstract

**Aim:** The use of artificial teeth in pre-clinical simulation clinic teaching of post-core techniques has clear educational benefits for students and staff. This study explored the reasons for selection and direct student experiences with artificial teeth in a recently conducted pre-clinical fixed prosthodontics post-core technique teaching program. **Materials and Methods:** An online anonymous survey was delivered to fourth year undergraduate dental students who had completed the fixed prosthodontics pre-clinical program seeking information on the choice of artificial or natural teeth and direct experiences. Quantitative data was summarized and qualitative data was clustered into topics. **Results:** A 100% response rate was received. Twenty-five (36%) of 70 respondents chose to use one or more artificial teeth for the post-core exercises which was predominantly driven by difficulty in sourcing appropriate natural teeth (59%) rather than educational benefit (13%). Forty-five (64%) chose not to use artificial teeth largely due to the cost of the teeth (49%). Direct student experiences in using the artificial teeth for post-core exercises were generally positive. **Conclusions:** As the first known research of its kind, within the limitations of this study, artificial teeth provided an appropriate and realistic simulation compared with extracted natural teeth and were easier to source for the post-core exercises of the pre-clinical fixed prosthodontics program. More widespread use of artificial teeth was limited by cost.

**Keywords:** Artificial tooth, curriculum, dental care, prosthodontics, students

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## INTRODUCTION

Fixed prosthodontics teaching in undergraduate dental curricula has traditionally included pre-clinical courses covering theory and practical techniques in crown preparation and post-core procedures. The importance of pre-clinical dental education has been demonstrated as a key factor in facilitating a smooth transition to the clinical setting.<sup>[1]</sup> There is an established positive correlation of pre-clinical grades with clinical grades in operative dentistry and fixed prosthodontics.<sup>[2]</sup>

Dental simulation clinic teaching has established itself as a mainstay in pre-clinical teaching for students to develop practical skills.<sup>[3]</sup> Simulation clinic teaching has been used extensively in both pre-clinical and end-point fixed prosthodontics teaching modalities where

students typically complete a sequence of formative practical exercises culminating in a summative practical assessment.<sup>[4]</sup> In some curricula, dental simulation clinic teaching has significantly replaced clinical practice.

Post-core restorations facilitate the reconstruction of endodontically treated teeth and present advantages over extraction and tooth replacement enabling patients to retain natural teeth for longer.<sup>[5]</sup> In the modern era of dentistry with an ever-increasing placement of dental implants, post-core procedures may be thought of as a

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forgotten art; however, they have an important role in restorative dentistry and prosthodontics particularly with adults retaining more teeth for longer.<sup>[6,7]</sup>

The normal purpose of a post is to retain the coronal restoration.<sup>[8,9]</sup> Post-core procedures are complex and require a high level of skill. It is, therefore, imperative undergraduate dental students are trained accordingly.

Traditionally, extracted natural teeth have been sourced for pre-clinical simulation clinic teaching of fixed prosthodontics and post-core techniques. In recent years, limitations have been encountered such as ethical barriers, cross-infection requirements, sourcing teeth with appropriate tooth structure, and sourcing teeth with appropriate root canal anatomy. The nature of variations in natural teeth limits the standardization, repeatability, and consistency of teaching and can result in a diverse range of student experience of learning.

The benefits of using artificial teeth in simulation teaching in fixed prosthodontics include standardization of teeth, standardization of techniques, life-like appearance, facilitation of repeatable practical demonstrations that are directly applicable to the student's tooth, and being readily available. The known shortcomings are limitations in the anatomical simulation of natural teeth, different surface textures compared with natural teeth, and the cost involved in obtaining teeth, models, and manikins.

As education philosophes and technology have evolved, the benefits of teaching alternative and modernized techniques in fixed prosthodontics have been established resulting in quality gains evidenced by students producing closer to ideal crown preparations.<sup>[10,11]</sup> Dental simulation teaching has expanded beyond the traditional manikin model to encompass virtual reality technologies.<sup>[3,12]</sup> Recent developments have been directed at 3D technologies associated with the creation of layered artificial teeth.<sup>[13-15]</sup> Artificial endodontic teeth have been produced and used in endodontic pre-clinical teaching with promising initial results,<sup>[16]</sup> but there have not yet been any reports for post-core teaching.

The fixed prosthodontics pre-clinical course at The University of Adelaide, Australia provides a comprehensive and intensive simulation clinic experience in crown preparations and post-core techniques for undergraduate students involving structured theory and practical elements. Although extracted natural teeth provide a high-fidelity experience, the dominant challenges in using natural teeth for post-core pre-clinical fixed prosthodontics procedures have been sourcing appropriate teeth and when sourced the compromised restorative state. Research specifically focused on undergraduate pre-clinical education in post-core techniques is scarce. More specifically there remains a dearth of evidence on the use of artificial teeth in the education of undergraduate students specifically in post-core exercises.

The aim of this study was to explore the reasons for selection and direct student experiences with artificial teeth in a recently conducted pre-clinical fixed prosthodontics post-core technique teaching program using a survey of student experience. The null hypothesis was that there was no significant difference between the reasons for selection and use of artificial and natural teeth.

## MATERIALS AND METHODS

### Context

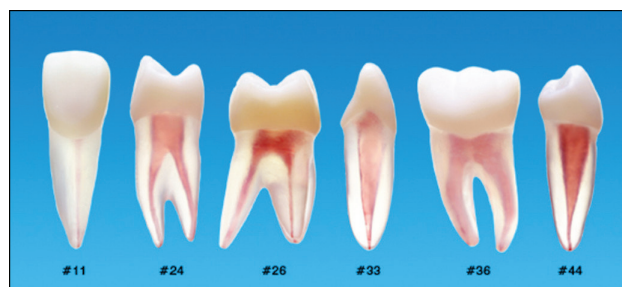
Fourth-year undergraduate dental students undertaking the fixed prosthodontics pre-clinical program at the Adelaide Dental School, The University of Adelaide were presented with an option to source extracted natural teeth or purchase artificial teeth [Figure 1] at A\$25 per tooth prior to the post-core component of the program. A total of six teeth were required for all post-core exercises. Any combination of artificial and natural teeth was permissible, all of which could be used in the same acrylic base model fitted to the manikin head. The teeth were manufactured using conventional moulding techniques, not three-dimensional (3D) layering. The use of the teeth for the set exercises followed a comprehensive fixed prosthodontics didactic program and was conducted in a dental simulation clinic.

### Survey development

Two surveys were developed according to whether students used artificial teeth (Survey 1) or natural teeth (Survey 2) for the post-core exercises in the fixed prosthodontics pre-clinical program [Table 1]. The questions were a combination of five-point Likert scale, yes/no, multiple choice, and open-ended questions and examined the choice of teeth, reasons for choice, and direct experiences and observations.

### Participants

All 70 fourth-year students were sent an email after finishing the program requesting completion of one of the two anonymous online survey links, administered using Survey Monkey (SurveyMonkey™, San Mateo, CA, USA).



**Figure 1:** Artificial tooth—Nissin Anatomical Pulp Cavity and Root Model [B22X Series] (Sourced from: [https://www.nissin-dental.net/products/DentalTrainingProducts/Parts/B22X\\_Series/index.html](https://www.nissin-dental.net/products/DentalTrainingProducts/Parts/B22X_Series/index.html))

## Statistical analysis

The surveys were conducted over a period of 1 week. All responses were anonymous. At the end of the survey period, the responses to five-point Likert scales, yes/no, and multiple choice questions were summarized in Microsoft Excel software (version 2016) and presented in tabulated form. Scores of 1, 2, 3, 4, 5 were assigned to the five-point Likert scale questions reflecting the degree of agreement. Qualitative data was clustered into topics and analysed in Microsoft Excel software (version 2016) and presented in tabulated form. A chi-square test of independence was performed for all comparisons of the reasons for selection and use of artificial and natural teeth using Microsoft Excel software (version 2016), with the level of significance set at  $P = 0.05$ .

## RESULTS

A 100% response rate was received. Of the 70 respondents, 25 (36%) chose to use one or more artificial teeth for the post-core exercises in the pre-clinical program, with 17 (68%) of these respondents choosing three or less of the possible six artificial teeth. Forty-five (64%) respondents chose not to use artificial teeth, choosing to use only natural teeth.

### Survey 1 (artificial teeth)

For the 25 respondents who used at least one artificial tooth, the reasons for choosing artificial teeth were dominated by difficulty in sourcing appropriate natural teeth (59% of responses) compared with 13% reasoning an educational benefit ( $P > 0.05$ ) [Figure 2].

When the direct student experiences of using artificial teeth were examined with open-ended questions, “ease of use” was established as a dominant positive aspect accounting for 52% of 71 responses ( $P > 0.05$ ). The main negative aspect was “unrealistic simulation of natural teeth” representing 50% of 64 responses ( $P > 0.05$ ).

When compared with natural teeth, 28% ( $n = 7$ ) found artificial teeth to have the same surface texture using a high speed bur, whereas 44% ( $n = 11$ ) found the artificial teeth a little harder ( $P > 0.05$ ); 56% ( $n = 14$ ) found the canals were a little easier to locate ( $P > 0.05$ ); and 36% ( $n = 9$ ) found the same ease of deviating or perforating from the obturated canal compared with natural teeth. Two of the 25 respondents reported perforating the artificial teeth ( $P > 0.05$ ).

### Survey 2 (natural teeth)

Of the 45 respondents who chose only natural teeth for post-core exercises, 49% of 79 responses reported the selection was due to “artificial teeth cost too much” ( $P > 0.05$ ) [Figure 3]. If given the choice again, 23 (51%) of the respondents would choose artificial teeth at the same cost.

For the 45 respondents who did not use any artificial teeth, if they were to use artificial teeth in the future the perceived benefits were dominated by “ease of use” (45% of 118 responses) ( $P < 0.05$ ) [Figure 4], whereas the perceived negative aspects focused on “unrealistic simulation of natural teeth” (48%) and “cost” (27% of 118 responses) ( $P > 0.05$ ) [Figure 5].

The average cost that the same respondents were willing to pay in the future for artificial teeth was A\$6.43 per tooth with 73% of respondents willing to pay A\$6 or less per tooth ( $n = 45$ ) ( $P > 0.05$ ).

**Table 1: Survey 1 (artificial teeth) and survey 2 (natural teeth) questions**

#### Survey 1 (artificial teeth)

- Q1 Of the six (6) teeth required for the post-core component of the pre-clinical program, how many artificial teeth did you use?
- Q2 What were your reasons for choosing artificial teeth for the post-core exercises in the pre-clinical program?
- Q3 When compared with natural teeth, how did you find the surface texture using a high speed bur of the artificial teeth for post-core exercises in the pre-clinical program?
- Q4 When compared with natural teeth, how did you find the ease of locating the root canals of the artificial teeth for post-core exercises in the pre-clinical program?
- Q6 Did you perforate an artificial tooth?
- Q7 When compared with natural teeth, how did you find the ease of deviating or perforating from the obturated canal of the artificial teeth for post-core exercises in the pre-clinical program?
- Q8 List three positive aspects of using artificial teeth for post-core exercises in the pre-clinical program
- Q9 List three negative aspects of using artificial teeth for post-core exercises in the pre-clinical program

#### Survey 2 (natural teeth)

- Q1 What were your reasons for choosing natural teeth for post-core exercises in the pre-clinical program?
- Q2 If given the choice again, would you consider choosing artificial teeth for post-core exercises in the pre-clinical program?
- Q3 If you used artificial teeth in the future, list three positive aspects of using artificial teeth for post-core exercises in the pre-clinical program?
- Q4 If you used artificial teeth in the future, list three negative aspects of using artificial teeth for post-core exercises in the pre-clinical program?
- Q5 What is the maximum cost per artificial tooth you would be willing to pay?

The null hypothesis was rejected. It was established there were significant differences between the reasons for selection and use of artificial and natural teeth. With an exception of the results presented in Figure 4, all the calculated P values were significantly greater than 0.05.

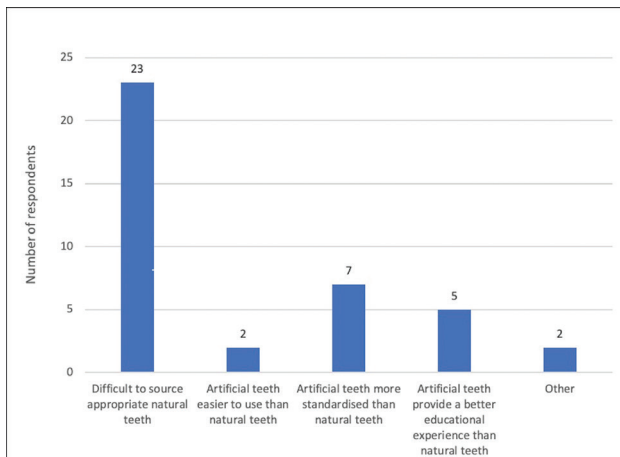
## DISCUSSION

### Direct findings

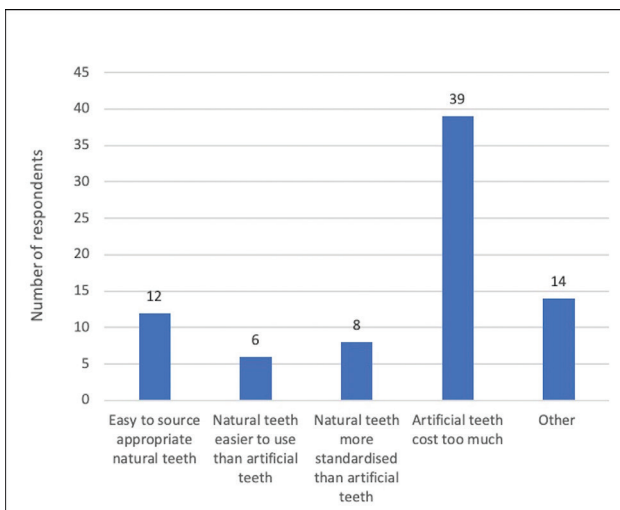
The study found a range of reasons for the selection of artificial teeth for post-core pre-clinical exercises but was predominantly explained by difficulty in sourcing appropriate natural teeth. Beyond ethical considerations, obtaining appropriate tooth types (single rooted, multiple rooted) with appropriate root anatomy, in a restorable state, in large numbers, and for large numbers of students is a challenge that obtaining artificial teeth from a dispensing machine overcomes.

For the 36% of respondents who used artificial teeth, cost was not reported as a major drawback. The dominant direct beneficial experiences of students who used artificial teeth was the ease of use and the main negative aspect was unrealistic simulation of natural teeth, which are somewhat contradictory. Further investigation is required but could in theory be reasoned by the pristine unrestored nature of the artificial teeth compared with the frequently heavily restored, diseased, or broken-down natural teeth. Artificial teeth were judged by respondents who used the teeth as similar to natural teeth in surface texture and ease of deviating from the obturated canal but slightly easier to locate the canal which reinforces the appropriateness of using artificial teeth in post-core pre-clinical programs.

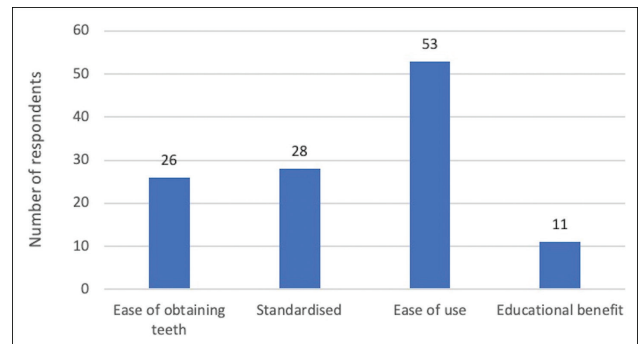
Contrastingly, it was apparent that cost served as an initial barrier to choosing artificial teeth over sourcing natural teeth as demonstrated by the 64% of respondents who chose not to use any artificial teeth. Students already have significant educational expenses and when posed with a decision to outlay further, they predominantly chose to source natural teeth at their own individual time and effort expense. Students have choices, their opinions can be influenced by a variety of factors, and in practical



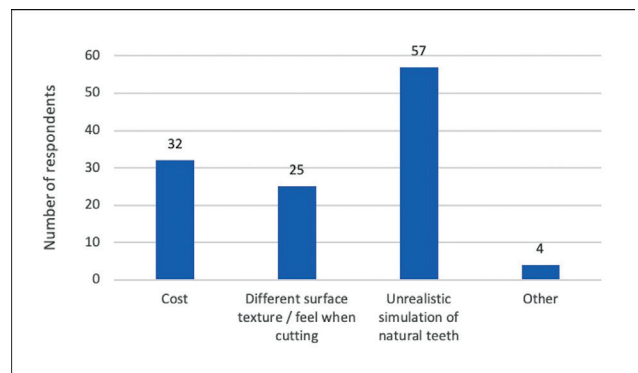
**Figure 2:** Reasons for choosing artificial teeth (multiple answers permitted) ( $n = 25$ , 39 responses)



**Figure 3:** Reasons for choosing natural teeth (multiple answers permitted) ( $n = 45$ , 79 responses)



**Figure 4:** If artificial teeth were used in the future, positive reasons for selecting artificial teeth (multiple answers permitted) ( $n = 45$ , 118 responses)



**Figure 5:** If artificial teeth were used in the future, negative reasons for selecting artificial teeth (multiple answers permitted) ( $n = 45$ , 118 responses)



terms it may have been a relatively simple decision of cost outweighing convenience.

The 64% of respondents who did not use artificial teeth perceived future potential benefits as ease of use but were concerned with the potential unrealistic simulation of natural teeth more than cost. Surprisingly, educational benefit did not feature highly in the responses. Students may have a different perspective to that of teaching staff, focusing more on the practicalities of sourcing teeth, associated costs, and ease of use rather than educational benefit. The ability to use standardized simulation teaching resources has clear educational benefits, where a consistent educational experience can be provided and repeated for all students in the class at different points in time. Students may perceive cost as a barrier to gaining educational benefit.

### Comparative research

There has been no known previous research in this specific field of the use of artificial teeth in post-core teaching of undergraduate students, as such direct comparisons are limited. Overarching surveys of curriculum structure, techniques taught, and materials used in undergraduate prosthodontics courses (that include fixed prosthodontic components) have been conducted at various points in time<sup>[17-20]</sup> and have fueled recommendations and publication of curriculum guidelines.<sup>[21]</sup> Surveys of student experiences have been performed in the broader prosthodontics educational context including self-report of confidence in undergraduate removable prosthodontic education<sup>[22]</sup> and effectiveness of preclinical courses in preparing students for patient treatment.<sup>[23]</sup> More specific research has focused on student experiences in fixed prosthodontics such as using 3D scanner technologies to more objectively assess student crown preparations,<sup>[24]</sup> teaching different crown preparation techniques,<sup>[10]</sup> and evaluating the effectiveness of different teaching methodologies using digital and real time technologies.<sup>[11]</sup> Each has proposed educational benefits.

An underpinning principle of successful pre-clinical fixed prosthodontics education is that simulation teeth should have an accurate and realistic representation of natural teeth while ideally circumventing the educationally limiting complexities in post-core technique teaching such as fine, blocked, and curved canals. In the present study, artificial teeth were predominantly reported to have the same or a little harder surface texture as natural teeth when using a high speed bur which tends to agree with a comparative study where the majority (71.1%) of the students thought there was not much difference in the tactile sense between natural teeth and the typodont teeth, notwithstanding the unknown brand of tooth used in the comparative study.<sup>[1]</sup> When coupled with the present study's finding that it was a little easier to locate the canals on artificial teeth than natural teeth, the initial use of

artificial teeth for post-core teaching appears to suggest a beneficial educational experience for students especially at the commencement level.

The limitations of using natural teeth for endodontic pre-clinical teaching have previously been recognized<sup>[25]</sup> and their use may not represent a completely beneficial educational experience at the beginner level considering the intricacies of the root canal system. The use of artificial teeth for endodontic pre-clinical procedures has been associated with promising initial results using traditionally mould-formed teeth<sup>[16]</sup> and 3D printed teeth,<sup>[26]</sup> but the tooth hardness has been criticized. Clearly, further research and development is required in this area.

### Artificial tooth development

The development of artificial teeth for use in simulation teaching has rapidly advanced in recent years. 3D printing of teeth with different layers may present reduced cost and manufacturing time benefits and their use has been found to have a positive impact on the educational experience of students performing post preparations.<sup>[14]</sup> However, the hardness of the teeth has received initial criticism<sup>[14]</sup> with new materials proposed to address this issue. The hardness of 3D printed teeth has not been widely analyzed specifically in post-core procedures and requires further refinement.

This was the first time artificial teeth had been included as an option in the post-core component of this study's pre-clinical program; therefore, no preceding student experiences were available. The manufacturing company of the artificial teeth proposed user benefits of a natural root form tooth model with anatomical pulp cavity, radiographic imaging ability, and a difference in cutting feel between the enamel and the dentin material similar to natural teeth.<sup>[27]</sup> The range of teeth is at present limited and being further developed.

### Clinical applications and the importance of post-core education

Extensive clinical research has been published in the field of post-core materials and techniques including reviews of the founding principles<sup>[28]</sup> and systematic reviews and meta-analyses that claim high success rates in anterior and posterior teeth.<sup>[29]</sup> The cumulative survival rate of post-core restorations has been reported at 86% at 10 years<sup>[30]</sup> with summary rates of root fracture of less than 2%,<sup>[31]</sup> but dependent on the post material and modulus of elasticity. However, the path to success is multi-factorial and especially influenced by the selected post system.<sup>[29,32]</sup>

Clinical practice has been reported as the key to competence and undergraduates' perceived competence in prosthodontics has been directly related to the number of treatments performed.<sup>[33]</sup> Pre-clinical education, as the

precursor to clinical experience, is an essential component in the undergraduate dental curriculum. In this context of performing a complex procedure usually due to the substantial loss of coronal tooth structure, and with a myriad of post systems available in the marketplace, it is critical graduating dental students have a grounding in the mainstream post-core systems. The teaching of post-core exercises still represents a key component of the undergraduate fixed prosthodontics programs in training dental students to be competent dentists.

### Limitations

The 100% response rate was an excellent result and has been reported in other studies of similar type<sup>[22]</sup> and location<sup>[34]</sup> involving student participants. Although representative of this particular student cohort, the study was conducted at a single dental school and the results may not be generalizable to students in other programs. The responses were taken at a single point in time after the completion of the pre-clinical program and gathered retrospective data. The demographic of gender distribution was not investigated and the study included a relatively small number of students who chose to use a relatively small number of artificial teeth. The results have a distinct educational focus and cannot be applied clinically. Nevertheless, in the context of limited previous research in this area, the present study's findings are encouraging and should serve as a sound precedent for further research.

### Recommendations

Based on the current available research, the author's proposal for future teaching of post-core techniques in a fixed prosthodontics pre-clinical program is to use artificial teeth for initial training leveraging the benefits of simplicity and standardization to build initial skills. When initial skills have been formed, proceed to further pre-clinical training on extracted natural teeth utilizing their realistic properties of surface texture and the unique features frequently encountered in natural teeth before progressing to the clinical setting. Natural teeth still have a role to play in the pre-clinical simulation clinic teaching of post-core techniques.

### CONCLUSIONS

Within the limitations of this study, artificial teeth provided an appropriate and realistic simulation compared with extracted natural teeth and were easier to source for the post-core exercises of the pre-clinical fixed prosthodontics program. More widespread use of artificial teeth was limited by cost.

### Ethical policy and institutional review board statement

Ethics approval was obtained from the Human Research Ethics Committee at The University of Adelaide (H-2020-106).

### Patient declaration of consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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### Conflicts of interest

There are no conflicts of interest.

### Author contributions

There are no conflicts of interest.

### Data availability statement

Data is available from the author on request

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